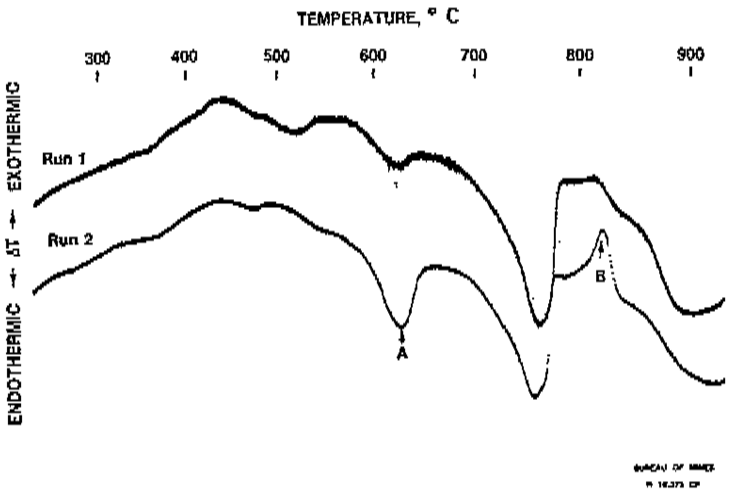

FIGURE 48. - Differential thermal analysis of sample from school ceiling, showing endothermic (A) and exothermic (B) peaks of serpentine. Run 1 is the sample as received; run 2 is a mixture of 95 pct of the as-received sample and 5 pct chrysotile.

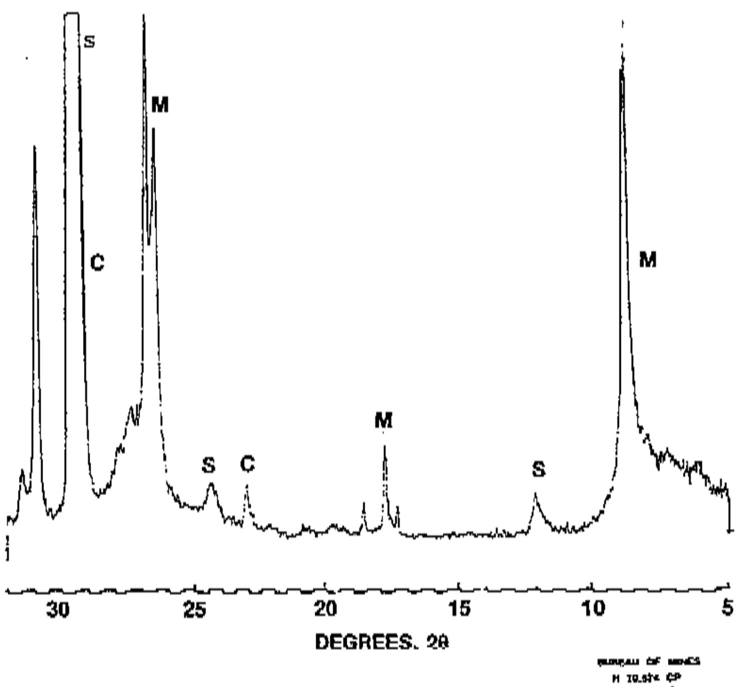

FIGURE 49. - X-ray diffractometer scan of sample from school ceiling, showing the presence of calcite (C), mica (M), and serpentine (S).

1.0 weight-percent. An X-ray diffractometer scan of the 2θ range for major serpentine peaks is shown in figure 49. The magnitude of the characteristic peaks for chrysotile are a function of several factors, including degree of fiber orientation and the type of milling or crushing used to process the sample. Also, the sensitivity of both methods is affected by the presence of other minerals that have characteristic thermal or diffraction peaks in the same region as those of the minerals of interest.

Some samples will be composed of a mixture of synthetic and natural fibers, such as the mixture of fiberglass and chrysotile shown in figure 50. Generally, it is not difficult to identify the synthetic fibers based on their larger diameter and the more uniform appearance.

Amphiboles and Talc

Asbestos-related health regulations are having a significant impact on the domestic talc industry from occupational exposure at the mines and mills and at various manufacturing plants that use talcs in their operations. Certification that the talc does or does not contain asbestiform minerals is important because the occupational health requirements are much more restrictive if the talc is designated as containing asbestiform serpentine or amphibole minerals.

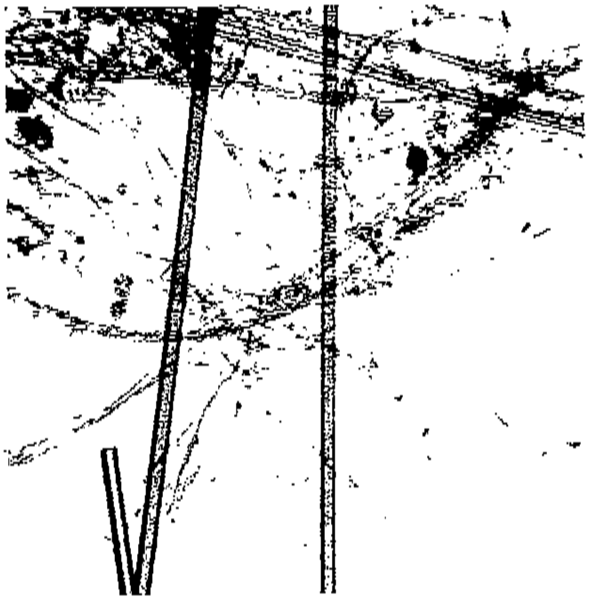

FIGURE 50. - Sample from university building, showing a mixture of chrysotile and fiberglass (X 140).

Talc is both the name of a specific mineral, $Mg_3Si_4O_{10}(OH)_2$, and a commercial term for a mixture of minerals ranging from essentially 100 percent talc to blends where the mineral talc is a minor constituent (12, 23). Semiquantitative estimation of the serpentine and/or amphibole mineral concentration, if present, can be obtained by X-ray diffraction and differential thermal analysis. Several talc deposits contain a variable amount of tremolite. Therefore, the essential question faced by the analyst is whether or not the tremolite is fibrous. Figure 51 shows the typical platy morphology of talc; no tremolite (amphibole) was detected in this sample by X-ray diffraction. Figure 52 illustrates the type of particles obtained from a mixture of tremolite and platy talc. The cleavage fragments of tremolite are typical of the nonasbestiform variety. Better judgment is required of the analyst with the type of sample illustrated in figure 53. This sample consists of platy talc, cleavage fragments of tremolite, and minor to trace amounts of fibrous tremolite. For this latter sample, the 3-to-1 aspect-ratio criteria would greatly overestimate the number of fibrous tremolite particles collected on air filters or other monitors.

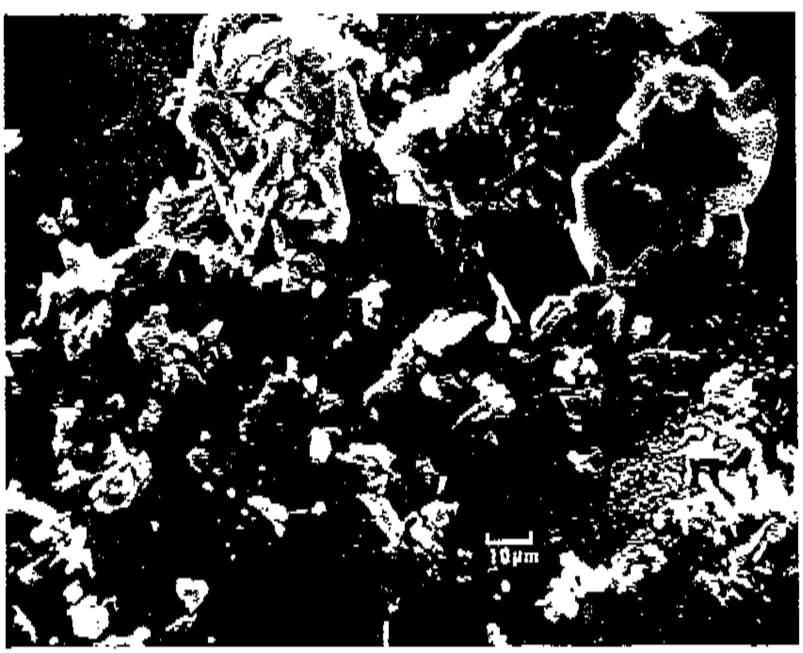

FIGURE 51. - Typical platy morphology of talc (X 600).

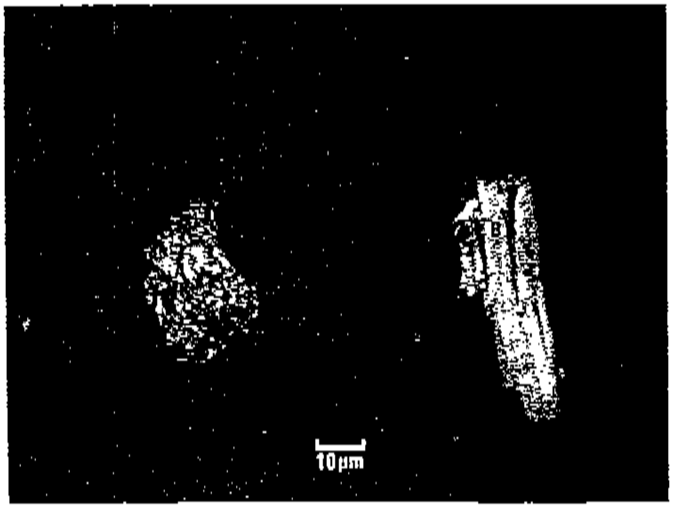

FIGURE 52. - Platy talc (A) and tremolite cleavage fragment (B) (X 640).

FIGURE 53. - Platy talc, tremolite cleavage fragments, and a fibrous tremolite particle (A) (X 400).

RESEARCH NEEDS

There are several areas in particulate identification-characterization where further research is warranted. Areas of research that are immediately applicable to asbestos are briefly summarized.

Commercially available electron optical instruments are generally limited to morphological characterization for mineral particles with diameters less than 0.2 µm. As pointed out in the identification-characterization section, both the signal-to-background ratio for energy dispersive X-ray spectra and the SAED pattern are significantly degraded for elongated particles less than 0.2 µm in diameter. Field emission electron optical microscopes with their higher vacuums and smaller beam diameter may have some advantages over conventional SEM instruments. Also, other microprobe techniques, in particular ion microprobe mass spectrographs and laser Raman microprobes, should be evaluated for particulate characterization.

Although electron microscopic methods can generally positively identify chrysotile in air and water samples, the quantitative aspects of the measurements need substantial improvement. Sample treatment and measurement errors need to be isolated from sampling variance. Because of the ambiguity of fiber counts, results should be reported both in mass equivalents and in fibers per unit volume.

Fundamental studies should be conducted to determine if there are unique chemical and physical characteristics of a mineral fiber as compared to elongated cleavage fragments. For example, the surface properties of chrysotile are similar to those of magnesium hydroxide, whereas the nonasbestiform varieties of serpentine have the surface characteristics of a silicate (30). Variations in surface properties, if any, between asbestiform particles and cleavage fragments of amphiboles should be investigated. Surface characterization techniques to be considered should include Auger electron spectrography and low-energy X-ray spectrography. Research at the University of Minnesota indicates that asbestos fibers have an extensive surface charge over the whole surface, whereas cleavage fragments have a significantly lower surface charge (40). Extinction angle measurements are another possible approach to distinguishing asbestiform from the nonasbestiform varieties of amphiboles (37).

There is a critical need to reexamine the 3-to-1 aspect ratio as a criterion for a mineral fiber. The aspect ratio for fibers from asbestiform minerals were as much as 200 to 1 or higher, whereas the ratio for cleavage fragments is about 3 to 1, as illustrated by the data in this report. The 3-to-1 aspect ratio may be valid for the industrial hygiene control of asbestos-processing plants; however, its applicability to existing nonasbestos mining and ore processing plants requires critical evaluation. There is also need to evaluate the restriction of the mineral particulate measurments to light optical microscopy because many particulates of interest, especially chrysotile fibrils, are not visible by this technique. Low-cost scanning electron microscopes are in the same price range as research-grade petrographic microscopes, and the skill requirements for the operator are comparable for both instruments.

Particulate measurements by microscopic procedures are time consuming and expensive. Two possible approaches to reducing the time and cost are (1) automation of the particulate identification-characterization measurements using computerized image analyzers and (2) development of chemical reagents that give a specific response with either chrysotile or the various asbestiform amphibole minerals. Using the chemical-reagent approach, mass-concentration values could be obtained by measurement of some response such as color, ultraviolet fluorescence, X-ray spectral intensity, etc.

Health studies related to inhalation and ingestion of fibers have been essentially limited to well-defined commercial types of asbestos. The fundamental question to be resolved is the biological effects of cleavage fragments compared with those of true mineral fibers. If shape and size are the critical parameters, the analyst could establish and measure suitable analytical parameters to monitor the particulates of interest. Likewise, if the health scientists find a correlation between health and the amount of trace metals, adsorbed organics, surface area, etc., the analyst can respond accordingly. Therefore, there is a primary need for an adequate quantity of well-characterized amphiboles and serpentine of both the normal and asbestiform varieties for use in health-related studies.

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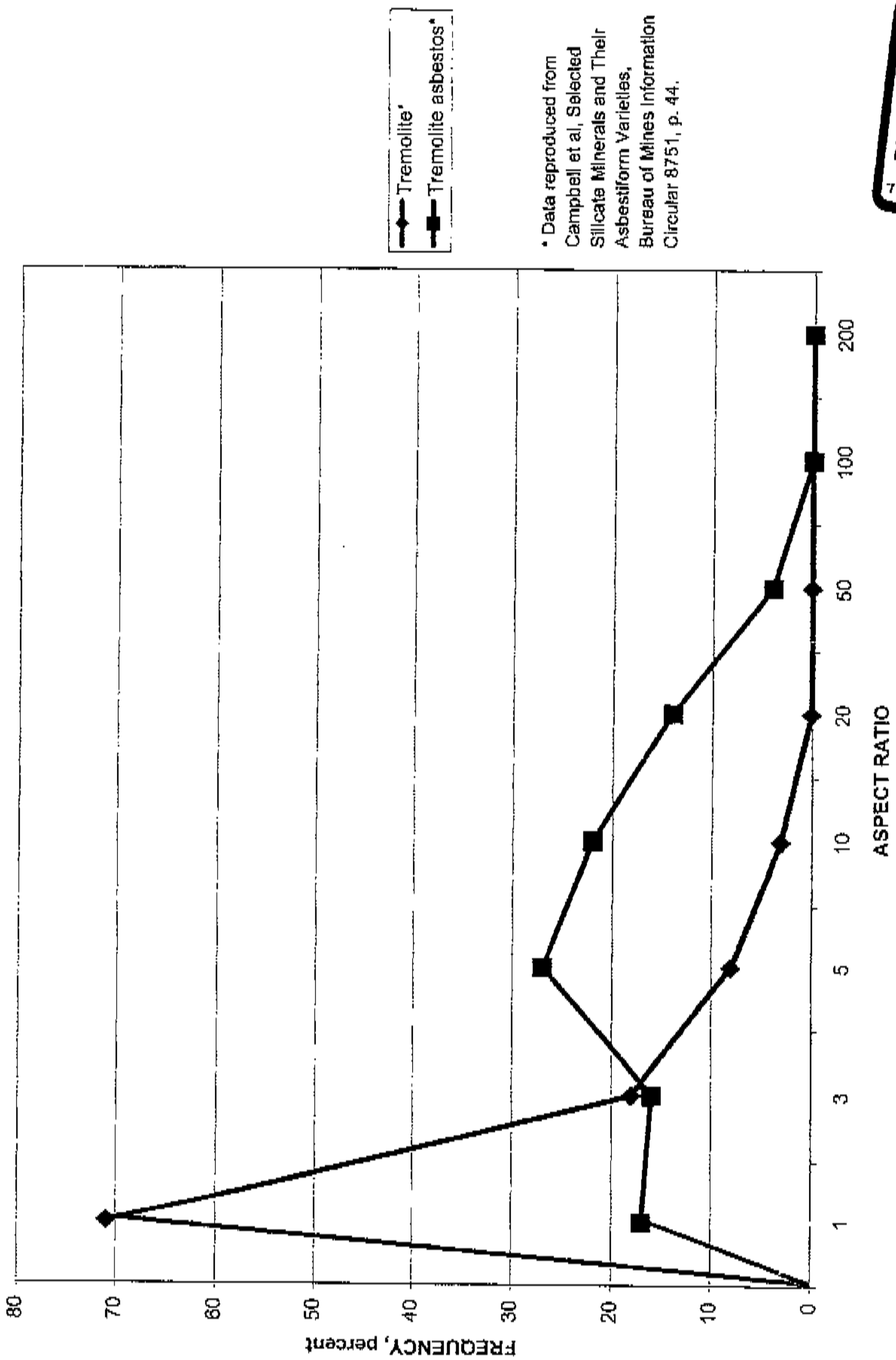

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